1,176,531

PATENT SPECIFICATION

DRAWINGS ATTACHED

1,176,531

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International Classification:—E 21 b 21/04.

COMPLETE SPECIFICATION

A Process and an Apparatus for Bringing Under Control an Unexpectedly Producing Well

I, ADRIANUS WILHELMUS VAN GILS, of Netherlands nationality, of C/o B.S.P. Co. Ltd., Seria, State of Brunei, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

When drilling a borehole for obtaining natural oir or gas it is customary to use a drill bit which is connected to the lower end of an extensible drill pipe having a diameter smaller than that of said drill bit. In consequence, when the drill bit is rotated during drilling, it drills a hole which is of larger diameter than the drill pipe.

Also, during drilling so-called mud is used which consists of water or oil mixed with clay and chemical additives which raise the specific gravity of the mud to give it a value higher than that of water. The quantity of admixed heavier substances determines the specific gravity of the mud and this can be altered according to circumstances.

In use, the mud is pumped down through the drill pipe, flows through one or more holes in the drill bit and passes upwards through the annulus between the drill pipe and the wall of the borehole already drilled. The mud thereby carries along the drill cuttings to the surface but it also, by its hydrostatic pressure, serves the purpose of supporting the wall of the borehole against collapsing.

On coming to the surface, usually the mud is freed of cuttings by precipitation and flows into a storage tank from which it is repumped by a piston pump into the drill pipe. Normally, the quantity of mud which is pumped into the hollow drill pipe is a little greater than that which returns from the borehole. this difference arising from the continuous deepening of the borehole. It will be understood that the pressure which the mud pump has to develop must be high enough to overcome the circulation resistance of the mud through the drill pipe, through the drill bit, through the surrounding annulus and through the other associated pipe lines.

During drilling, it sometimes happens that, before the desired depth is reached, a layer formation is bored containing a substance such as oil, gas or water under pressure. By the pore pressure in this formation this substance can penetrate into the borehole, at least if this pressure is higher than the hydrostatic pressure of the mud at the bottom of the borehole, and the well becomes producing. The inflowing substance then mixes with the mud in the annulus around the drill pipe and causes a greater volume to flow from the borehole than is pumped into it. This can be observed by a rise in the level in the mud tank. If this process is allowed to proceed unhindered, all the mud around the drill pipe would be substituted by the inflowing oil, water or gas, the hydrostatic head pressure in the annulus in the vicinity of the bit would steadily decrease and eventually the well would blow out at the top of the borehole.

In order to prevent this, blow out preventors are customarily arranged for each drilling operation. These consist generally of two half rings covered with rubber which are placed around the drill pipe and which are pressed against the latter when its rotation is stopped, thereby closing off the annulus at the top. Before closing off the annulus in this manner, however, the mud pump must, of course, be stopped.

For continued drilling to deepen the borehole, the latter must be filled with mud

of greater specific gravity to prevent continued inflow of the unwanted substance. The required specific gravity of the mud may be derived from the pressures in the drill pipe indicated by a manometer on the surface and from the depth of the borehole. When the well starts producing, however, it takes some time before one can detect this condition by observing a rise of the mudpit level or otherwise, and during the delay interval the pressure in the annular space around the drill pipe will alter because the influx of the unwanted oil, gas or water is continued. When pressurised gas, oil or water flows in, as described, this pressure will rise eventually and a higher pressure will occur at the well head. Moreover, the mud in the annulus becomes contaminated with the lighter pressurised substance and consequently the hydrostatic head of the original, already too light mud column is further reduced. On the other hand, at this stage the drill pipe remains completely filled with mud without contamination by the inflowing oil, water or gas, and consequently the pressure at the top of the drill pipe, although increased, is lower than the pressure at the top of the surrounding annulus.

It will be appreciated that when the well is closed the inflowing gas or other pressurised substance connot expand and remains practically at its original pressure and exerts a pressure below on the mud column with which the hole is filled. The increase of pressure at the top of this mud column in the annulus may result in a breakdown of the wall of the well, in which case the contents of the well will break through to the surface outside the drilled borehole. This danger, referred to as cratering, does not arise immediately on closing the well, but the risk increases if the well is closed for a substantial time. Therefore, normally, the well annulus will be re-opened as quickly as possible, a restriction is introduced at the discharge end, and further mud is pumped into the drill pipe, under sufficient pressure for the deficiency of hydrostatic head pressure of the too light mud column to be compensated by increased hydraulic counter pressure, with the object of preventing a further inflow of the unwanted pressurised substance.

During this operation, the specific gravity of the mud is also usually increased.

In practice, however, it is extremely difficult to adjust the resistance at the annulus discharge and the pumping pressure to such an extent as to ensure either that the counter pressure is not too small, in which case the well would continue to produce and the mud would continue to be mixed with the inflowing substances from the formation, or that this counter pressure does not become too high whereby excessive loss of mud will occur and cratering or breakdown of the well may take place.

An object of this invention is accordingly to control an unexpectedly producing well under the conditions described, without risk of excessive loss of mud or breaking down of the well.

In the method according to the invention for bringing under control an undesirably producing well, mud heavier than the mud discharged from the well is pumped into the drill pipe by means of the energy of the mud discharged from the well.

As long as the mud has not the required specific gravity and consequently exerts insufficient hydrostatic pressure on the formation, the formation will continue to produce, and whilst producing, the quantity of mud then pumped into the well is smaller than the quantity emerging from the well. Under these conditions, it is not possible to pump in as much mud as is emitted. If a greater quantity could be pumped in than is emitted the pressure in the well would greatly increase whereby the formation in which the borehole has been drilled would crater and break down.

If more mud emerges from the well than is pumped through the drill pipe, the well would normally tend to become empty in course of time, but as long as the mud specific gravity remains too low, the formation will continue to produce and make up the difference in volume.

If, however, the mud in the drill pipe has the right value of specific gravity the hydrostatic pressure will balance the pressure of the unwanted substance in the formation and the well will then cease to produce. Neglecting any hydraulic pumping pressure present, no pressure can then be read off a manometer connected to the top of the drill pipe at the surface.

The pressure at the surface in the annulus will now be determined solely by the difference between the weight of the mud column in the drill pipe which has now the required specific gravity, and the weight of the column of lighter mud, mixed with formation substances, which is still present in the annulus. Now that the formation no longer produces, this column of lighter mud in the annulus can then also be replaced progressively by the heavier mud to fill the well completely with the latter.

An apparatus suitable for use in carrying out the method in accordance with the invention comprises a pump means for pumping heavier mud into the drill pipe, conduit means for directing said heavier mud from said pump means to the drill pipe, driving means for said pump means, conduit means for directing mud from the

discharge of the well to said driving means, said driving means being responsive to, and driven by, said mud from the discharge of the well.

Preferably, in said apparatus, said pump means is a piston pump having a first active piston surface, a second active piston surface of smaller area than said first surface, said pump being driven by the pressure of said mud from the discharge of the well acting against said first active piston surface, said second active piston surface driving said heavier mud into said conduit means to said drill pipe.

The operation of the apparatus during the process of bringing the undesirably producing well under control may be considered as separated into two stages, as follows:

Stage a. The mud pumped into the drill pipe is not heavy enough, and an increased pressure exists at the surface in the drill pipe whilst the volume of mud in the annulus is increased by inflowing pressurised substance from the formation.

Stage b. The drill pipe is filled with mud of the required specific gravity, the pressure at the surface in the drill pipe falls and the hydrostatic pressure of the mud column in the drill pipe becomes as great as the pressure in the formation which therefore ceases to produce anymore. The pressure at the surface in the annulus at this stage equals the difference in weight between the mud column in the drill pipe and that in the annulus.

Supply of the heavier mud to the well so as to replace completely all the lighter mud in the annulus may then be maintained by a low pressure centrifugal pump which can continue operation when the pistons of the piston pump stop reciprocating, use of this centrifugal pump now being possible because of the fall of pressure at the surface in the drill pipe.

During the entire process, no artificial counter pressure is produced to try to balance the formation pressure so no damage is likely to be caused to the borehole.

The well is brought fully under control when the entire borehole has been filled with the heavier mud of the required weight. There is then no difference in pressure at the surface between the annulus and the drill, and the apparatus ceases to operate because the fluid discharge of the well ceases to provide energy.

Thereafter, the well can be re-opened and the drilling is proceeded with in the normal way.

The invention will now be further described, by way of example, with the aid of an embodiment shown in the accompanying drawings.

In said drawings,

Fig. 1 is a cross section of a typical bore hole together with some associated equipment required for drilling the hole;

Fig. 2 is a side view of the apparatus comprising the embodiment herein described;

Fig. 3 is a cross section of this apparatus along the line III-III in Fig. 2, seen in the direction of the arrows;

Figure 4 is a cross section of the apparatus along the line IV-IV in Figure 2, seen along the arrows;

Figure 5 is a detail view, on a larger scale, of part of Figure 2; and

Figure 6 is a cross section along the line VI-VI in Figure 5.

In Figure 1, reference numeral 1 indicates the hollow drill pipe to the lower end of which a drill bit 2 is fixed, the latter having a greater diameter than the drill pipe 1. Consequently, there is an annular space 3 around the drill pipe 2. The drill pipe 1 is suspended on a hook 4 of a derrick which is suspended in a drilling derrick structure 5. The drill pipe 1 can be rotated at the surface by means not illustrated, as a result of which bit 2 crushes the rock under the drilling apparatus.

To the upper end of the drill pipe 1 a hose 6 is connected through which is pumped mud which passes into the hollow drill pipe 1 and which penetrates, through holes in the bit 2, into the annulus 3 so as to flow upwards and carry along the crushed rock. The mud normally overflows the upper end of the well and flows through a mud ditch (not shown) to a sediment tank (also not shown) in which the rock dust precipitates from the mud. Thereafter, the mud flows to a storage tank (also not shown) and is then pumped by a piston pump (also not shown) through a pipe line 9 and the hose 6, back into the upper end of the drill pipe 1.

At the place where the drill pipe emerges from the ground there is provided a blow out preventor which is shown schematically at 10 in Figure 1. This blow out preventor can consist of two half rings which can be pressed around the drill pipe 1 so as to close off the annulus 3. Adjacent the surface, a manometer 11 indicates the pressure in the annulus 3 and a manometer 12 connected to the mud supply line 6, 9 indicates the pressure in the drill pipe. To the annulus 3 and beneath the blow out preventor 10, a pipe line 14 is connected by way of valve 15 and a relief device 16.

Further equipment additional to that mentioned and illustrated is also required but this is as used in normal drilling practice and is well known in the art.

In the present embodiment of the invention, the lines 9 (through pipe 30) and 14 are connected to a control apparatus

of which the principal parts are shown in Figs. 2, 3 and 4. If during the drilling operation a pressurised substance such as gas, oil or water from a rock layer formation flows into the well in an unwanted manner, the rotation of the drill pipe 1 carrying the drill bit 2 is stopped and the blow out preventor 10 is closed. The gas, oil or water flowing into the well dilutes the mud in annulus 3 and produces a difference in pressure between the annulus and the interior of the drill pipe 1.

Referring now to Figures 2 to 6, the control apparatus shown therein has a base 20 with two upwardly extending supporting members 21. On these supporting members 21 is carried a housing 22 comprising two similar cylinders 23, 23, lying in alignment as indicated in Figure 4. In each cylinder 23 a movable piston 24 is provided, said pistons 24, 24, being connected to each other by a common piston rod 25. The cylinders 23, 23, are closed at their outer end by end caps 26 and their inner ends are in communication with exhaust valves 28 in housing parts 22′ by passages 27, which exhaust valves 28 are biassed by springs 29. The discharge sides of these valves 28 are connected with a T-shaped discharge piece 30′ which connects with pipe line 30.

The closed ends of the cylinders 23 are both connected by pipes 33, 33, with valve housings 34, 34. Both valve housings 34, 34. are identical and each has an admission valve 35 and a discharge valve 36 interconnected by a common spindle 37 which also carries an air piston 38 operating in an air cylinder 39 in the lower part of the valve housing 34. By admitting or discharging compressed air above or beneath the air pistons 38, as hereinafter described, the valves 35 and 36 may be opened or closed.

As shown, the pipe lines 33, 33, open into the spaces between the valves 35 and 36. Each admission valve 35 can connect the respective associated pipe line 33 with the line 14 which is connected to the well annulus 3 beneath the blow out preventor 10. In the open position of either of the admission valves 35, mud therefore flows from the well into respective pipe line 33 and into respective cylinder 23 against the piston surface 24a.

Each discharge valve 36 can connect the respective pipe line 33 with a discharge line 40 through which the mud flows away to the mud tank. If, therefore, the four valves 35 and 36 are moved in the correct rhythm the pistons 24 will go to and fro by energy which is delivered by the well. These pistons thereby draw into the cylinders 23, 23, heavy mud, on the side of their opposed surfaces 24b, 24b, which flows in through the pipe lines 42, of which only the end openings can be seen in Fig. 4.

Each of these lines 42 leads from a valve housing 43 containing a suction valve 44. The valve housings 43 for each cylinder 23 are connected with a common suction line 45 which is the delivery line of a low pressure electricaly driven centrifugal pump 46 supplying the heavier or weighted mud via valve 47 from the mud tank 48 (see Figure 2).

The mud coming through the pump 46, the suction valves 44, and the lines 42 into the cylinders 23, is forced out by the pistons 24, 24, on their reverse strokes, through the delivery valves 28 and the pipe line 30 to the drill pipe 1 (see Fig. 1). For this to occur, it is essential that the valve 31 is opened and that the valve 32, in the portion of pipe line 9 through which the mud is supplied in normal drilling procedures, is closed.

As the effective areas of the surfaces 24*b* of the pistons 24, which force the heavier mud to the pipe line 30, are smaller than the areas of the surfaces 24*a* of the pistons upon which the pressure of mud supplied from the well through the pipe line 14 acts, with corresponding differences in swept volumes, the quantity of heavier mud pumped into the well will be smaller than that of light mud flowing from the well. Therefore, there should never occur a too high pressure in the well by which the well wall would break down and cause a side-crater to be produced. This would, as already explained, render the well useless.

For correctly moving the inlet valves 35 and 36 the following air supply dividing device has been provided.

In each cylinder 23, in the vicinity of its end cap 26, a rotatable rod 50 projects inwardly and transversely through the cylinder wall (Fig. 4). An arm 51 is fixed on the inner end of this rod 50. Also, on the outer end of each rotatable rod 50 an arm 52 is fixed as indicated in Figs. 2 and 3. The ends of these arms 52 are pivotally connected to a rod 53. When a piston 24 reaches its outer position it presses away the arm 51 lying in the respective cylinder 23, thereby causing the outer arm 52 to rotate and move the connecting rod 53 longitudinally. As a consequence thereof, the arm 51 lying in the other cylinder 23 will also move. At the end of the reverse stroke of the pistons 24, the connecting rod 53 will, therefore, move back again. As the pistons 24, 24, move continuously, therefore, the connecting rod 53 is caused to move to and fro.

This movement of the rod 53 is used to admit and discharge compressed air to the cylinders 39 of the air pistons 38 which control the inlet valves and the discharge

valves 35 and 36.

For this purpose, two rings 54 are rigidly fixed on the connecting rod 53 (see Figures 5 and 6), between which lies a roller or pin 55. This roller or pin 55 is connected to an arm 56 which is fixed to a rectangular shaft 57 which is rotatably mounted on a column 58. This column 58, together with air supply dividing device housing 61, are mounted on a bracket 80 carried by housing 22.

On the rectangular shaft 57 is fixed a cross beam 59 of which the free ends are each connected by a lever pin 60 with a set of air valves which are contained in housing 61 and one of which will be described with reference to Figure 6.

Each set of valves has a flat inlet valve 62 with seat 63 and closing spring 64 and a ball form discharge valve 65. Both valves 62 and 65 are connected by a valve spindle 66. The seat 67 of the ball discharge valve 65 is carried by a tubular part 68 having discharge openings 69 opening to atmosphere. The tubular part 68 is otherwise closed at the top and is provided at its upper end with an elliptical eye 70 through which the lever pin 60 passes.

If the lever pin 60 descends, the tubular part 68 slides downwards, between sealing rings 72, through a cover 71 of the valve housing 61. The valve seat 67 then engages with the ball valve 65 and, with continued downwards movement, the inlet valve 62 is formed open. Then, air under pressure will flow from compressed air admission line 73 through the opened valve 62 into the line 74.

The pipe line 74 carries, as shown in Figs. 3 and 4, the compressed air to above one of the air pistons 38 and to beneath the other air piston 38. The air at the opposite sides of these air pistons flows back from the air cylinders 39 through the pipe line 75 to the air supply division device and, through its opened ball valve, to atmosphere. When the position of all these air valves is changed on the backstroke of the connecting rod 53, the compressed air then flows through the pipe line 75 to the air cylinders 39 and the air return is through the pipe line 74.

The apparatus operates as follows. If it appears from a rise of the level of the mud surface in the mud tank that there is an influx into the well, rotation of the drill pipe 1 is stopped and operation of mud pump (not shown) is also stopped. Furthermore, the blow out preventor 10 is closed and it is ensured that the valve 32 in the pressure line 9 of the mud pump is also closed. As the valve 15 in pipe line 14 is closed during in normal operation, the well is now completely sealed. From the pressure indicated by the manometer 12 and from the known depth of the well, the required density or specific gravity of the heavier mud for a continuation of the drilling can be calculated. Increase in this specific gravity is achieved by admixing heavy filler material to weight the mud. The valve 15 in the pipe line 14 is then opened as soon as possible, and so is the valve 31 in the pipe line 30, which pipe lines lead to the above-described apparatus. The centrifugal pump 46 is started. The high pressure in the pipe line 14 acts on the larger area surfaces 24*a* of the pistons 24 and the lower pressure in the pipe line 30 acts on their smaller area surfaces 24*b*. The pistons 24 will then both move and the air supply division device comes in action by which the inlet and the discharge valves 35 and 36 are displaced. By the centrifugal pump 46, heavy mud is supplied to the small acting surfaces 24*b* of the pistons 24 through the lines 42 and this mud is then delivered under pressure through the pipe line 30 into the drill pipe 1.

The greater the difference in pressure between the annulus and the drill pipe, the more rapidly the apparatus will operate, and after some time, the mud of the original relatively low specific gravity in the drill pipe is replaced by heavier weighted mud of the required increased specific gravity, at which stage the influx of further gas, oil or water into the well will cease.

The pistons 24, 24, may then stop reciprocating, but the centrifugal pump 46 will maintain the valves 44 and 28 open and will continue to supply mud to the drill pipe, but under these conditions the quantity of mud discharged from the well will not exceed that pumped in.

When the well is completely filled with the heavier mud there will then be no difference in pressure between the annulus 3 and the drill 1, and operation of the control apparatus is discontinued, the electrically driven centrifugal pump is stopped, the valves 15 and 31 in the pipe lines 14 and 30 respectively leading to the apparatus are again closed, and the valve 32 in the pipe line 9 and the blow out preventor 10 are opened.

The drilling can then be proceeded with in the normal way.

WHAT I CLAIM IS:—

1. A method for bringing an undesirably producing well under control comprising the step of pumping a mud heavier than the mud discharged from the well into the drill pipe by means of the energy of the mud discharged from the well.

2. A method for bringing an undesirably producing well under control comprising the steps of closing off the discharge of the well, discontinuing the normal pump-

ing of mud into the drill pipe, directing mud from the discharge to a pump for pumping heavier mud into the drill pipe, and pumping the heavier mud into the drill pipe using the energy of said directed mud to operate said pump.

3. A method according to claim 2, wherein the weight of the mud pumped into the drill pipe is gradually increased until the well stops unwanted production.

4. An apparatus suitable for use in bringing an undesirably producing well under control in accordance with the method of claims 1 and 2, said apparatus comprising a pump means for pumping heavier mud into the drill pipe, conduit means for directing said heavier mud from said pump means to the drill pipe, driving means for said pump means, conduit means for directing mud from the discharge of the well to said driving means, said driving means being responsive to, and driven by, said mud from the discharge of the well.

5. An apparatus according to claim 4, wherein said pump means is a piston pump having a first active piston surface, a second active piston surface of smaller area than said first surface, said pump being driven by the pressure of said mud from the discharge of the well acting against said first active piston surface, said second active piston surface driving said heavier mud into said conduit means to said drill pipe.

6. An apparatus according to claim 4 or 5, in which a centrifugal pump is provided to maintain the supply of the heavier mud of the required weight to completely fill the whole well after the drill pipe has become filled with said heavier mud and the well has ceased to produce.

7. A pump according to claim 5 or claims 5 and 6, characterised in that the piston pump has two similar pistons, connected by a common piston rod, which each have first and second active surfaces of different effective area.

8. A pump according to claim 5, 5 and 6, or 7, characterised in that inlet valves and discharge valves for controlling the flow of the mud from the discharge of the well which is passed to the piston pump are moved by a piston operated by air under pressure.

9. A method for bringing an undesirably producing well under control substantially as herein described with reference to the accompanying drawings.

10. An apparatus suitable for use in bringing an undesirably producing well under control, said apparatus being constructed and arranged substantially as herein described with reference to the accompanying drawings.

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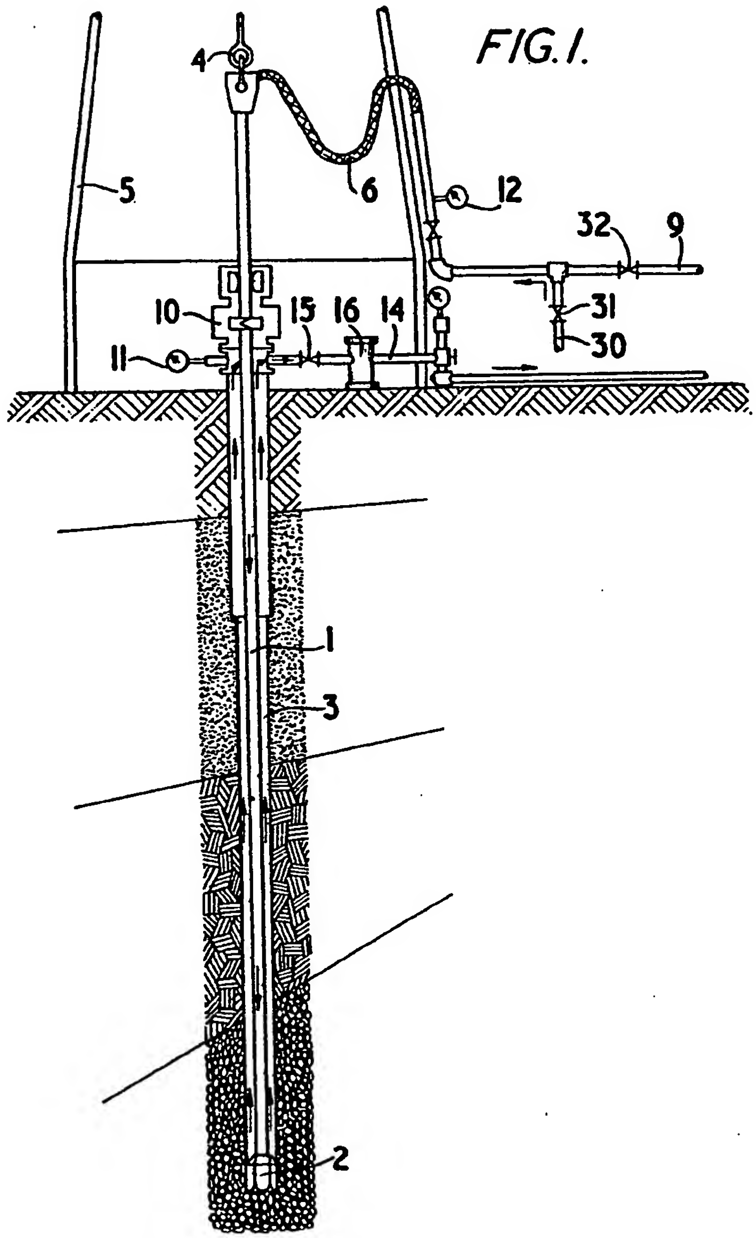
SHEET 1

FIG. 1.



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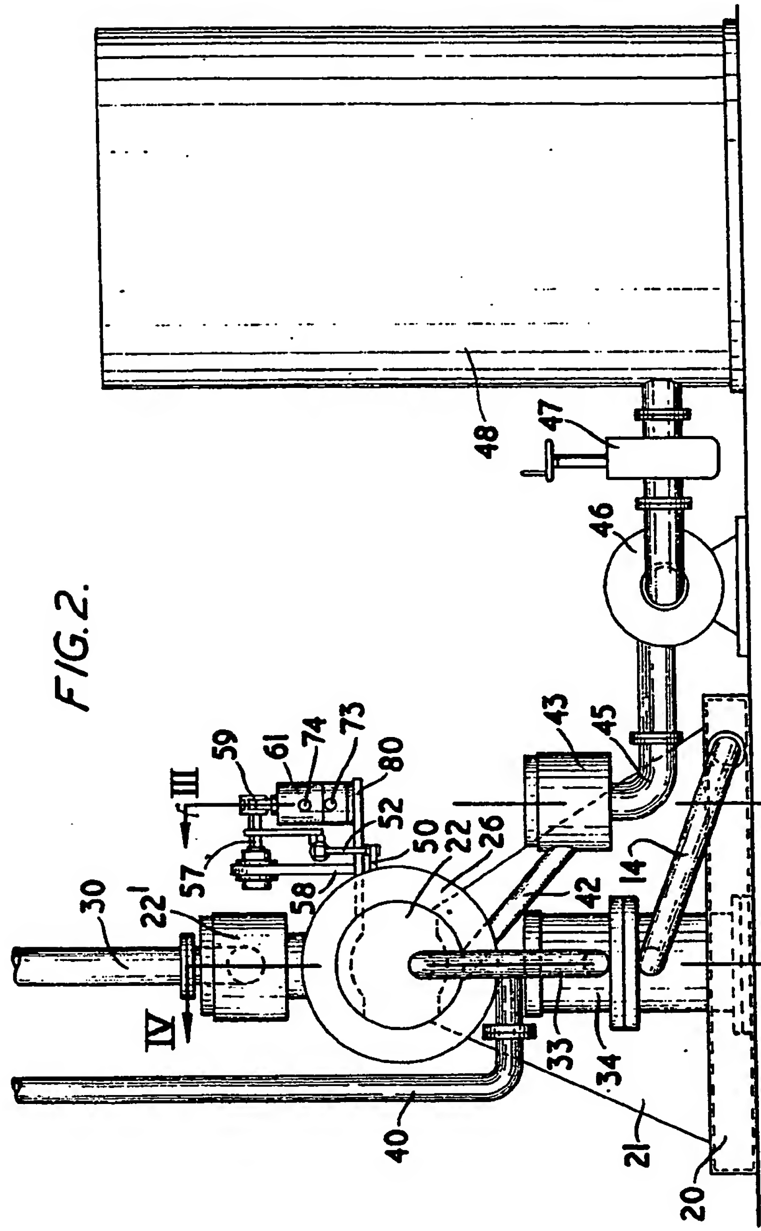
SHEET 2

FIG. 2.



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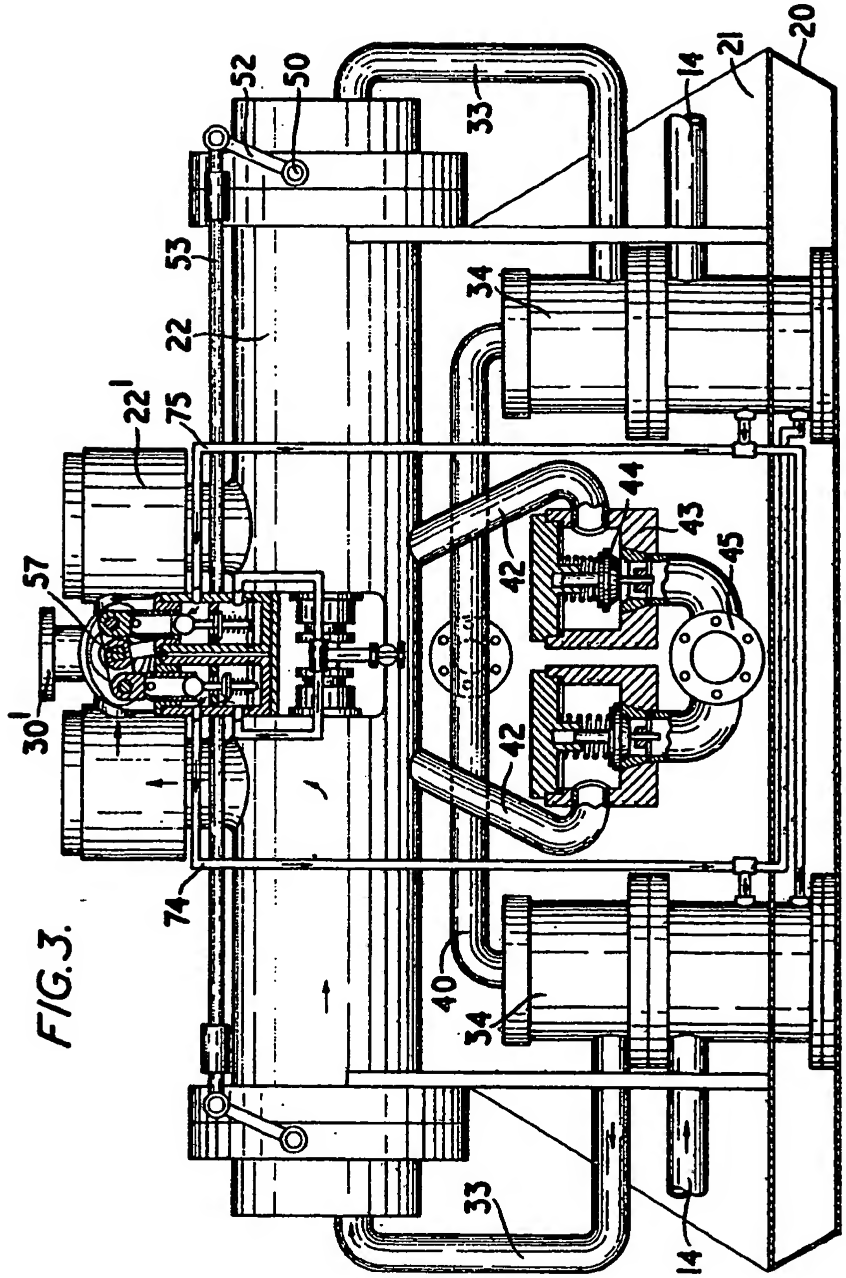

FIG.3.

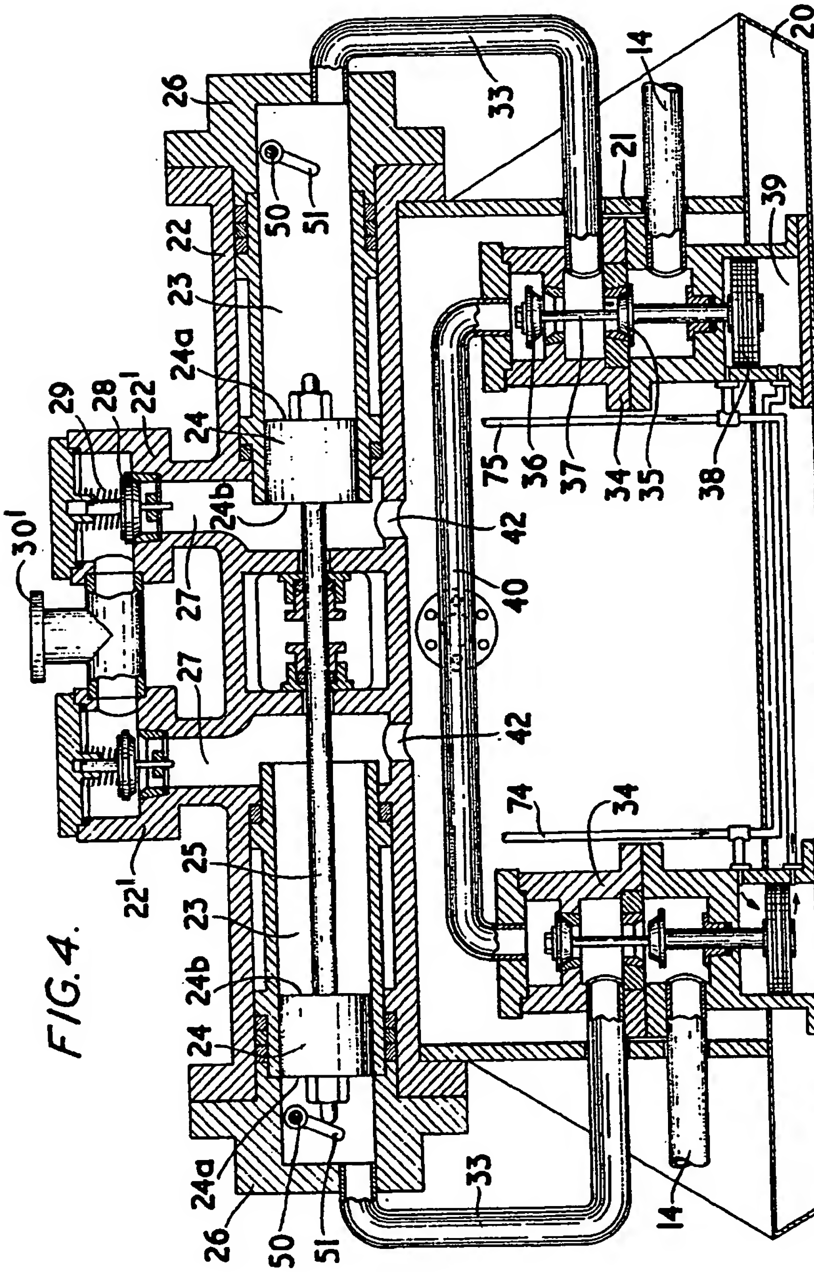
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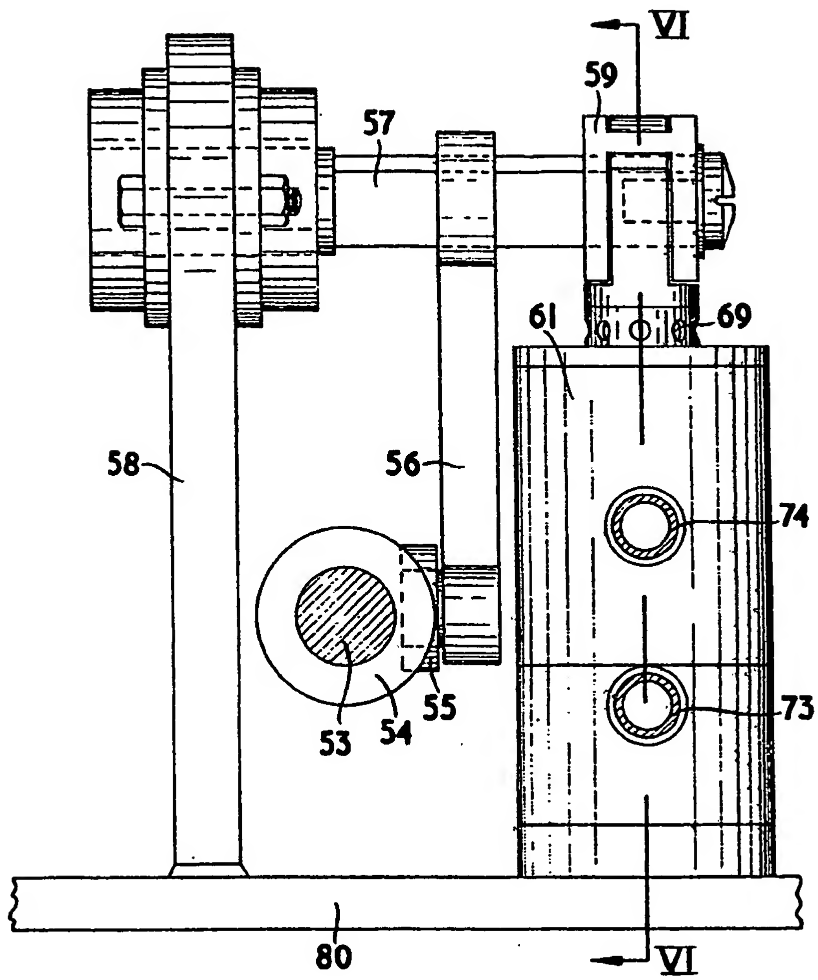
FIG. 4.

FIG. 5.



1,176,531 COMPLETE SPECIFICATION
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SHEET 6

FIG. 6.